" An Experimental Determination of the Variation of the Critical
Velocity of Water with Temperature." By E. G. COKER,
M.A. (Cantab.), D.Sc. (Edin.), Assistant Professor of Civil
Engineering, and S. B. CLEMENT, B.Sc., Demonstrator of Civil
Engineering, both of McGill University, Montreal. Commu-
nicated by Professor OSBORNE REYNOLDS, F.R.S. Received
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(Abstract.)

The change from stream-line to eddy motion in water was first
examined by Osborne Reynolds, who in his earlier experiments, intro-
duced colour-bands into a glass pipe in which water was flowing, to
indicate the change in the motion, and later observed the resistance
encountered in pipes over a great range of velocities.

The results of these experiments, and a consideration of the equations
of motion, enabled him to express the laws relating to the critical
velocity of water in pipes by the exceedingly simple equation

$$v_c = k \frac{\mu}{r\rho},$$

where v_c is the critical velocity of water, r is the radius of the pipe, μ is
the viscosity of the water, ρ is the density, and k is some constant.

In the original experiments the range of temperature was very
limited, and it was pointed out that " it would be desirable to make
experiments at higher temperature, but there were great difficulties
about this, which caused me, at all events for the time, to defer the
attempt." It does not appear that such experiments have since been
made, and although the difficulties were great, it was resolved to
test the law through a much greater range than had hitherto been
attempted.

Preliminary experiments showed that at temperatures beyond 50° C.
the losses due to conduction and radiation were large, and that
elaborate arrangements would be required to obtain reliable results. It
was therefore decided to determine the variation of the critical velocity
over a range extending from about 4° C. to 50° C., which seemed to be
sufficient as a test of the law, and, with ordinary precautions, only
necessitated small corrections for the effects of conduction and radia-
tion. The resistance method used by Osborne Reynolds in his later
experiments was employed, the arrangement only differing from his in
details, such as the use of pressure chambers giving a continuous
opening at the ends of the $\frac{3}{8}$-inch pipe examined, the employment of an
inverted U-tube for measuring the pressures, and the weighing of the
discharge.

Numerous experiments at different temperatures were made when stream-line motion was maintained in the pipe, and the relation of velocity to slope of pressure was determined by logarithmic plotting, giving a series of lines, the "logarithmic homologues" at different temperatures. The positions of these lines were found to be in substantial agreement with those calculated from the equations of motion. Similar experiments for eddy motion were made and the logarithmic homologues were also plotted, and their intersections with the corresponding ones for stream-line motion determined. These intersections give the minimum critical velocity, and were found to lie very approximately on a straight line in the diagram.

The law of variation of critical velocity, v_c, with temperature was found to be

$$v_c^{-1} \propto 1 + 0 \cdot 03368\mathrm{T} + 0 \cdot 000156\mathrm{T}^2,$$

where T is the temperature Centigrade, which agrees very closely with the known variation in the viscosity of water, viz.,

$$\mu^{-1} \propto 1 + 0 \cdot 03368\mathrm{T} + 0 \cdot 000221\mathrm{T}^2;$$

and it may, therefore, be concluded that over the range of temperature examined the critical velocity of water in small pipes varies directly as the viscosity.

"Isomeric Change in Benzene Derivatives—The Interchange of Halogen and Hydroxyl in Benzenediazonium Hydroxides." By K. J. P. Orton, Ph.D., M.A., St. John's College, Cambridge, Demonstrator of Chemistry, St. Bartholomew's Hospital. Communicated by Professor H. E. Armstrong, F.R.S. Received December 1,—Read December 4, 1902.

In discussing the laws which govern substitution in the case of benzenoid compounds, Armstrong, in 1887, drew special attention to the peculiar behaviour of amido- and hydroxy-compounds, from which he inferred that the phenomena of substitution were less simple than was commonly supposed. He showed that there was evidence that the formation of para-derivatives was preceded by that of an isomeric compound formed by the displacement of the aminic hydrogen or hydroxylic hydrogen, and pointed to the probability that this might prove to be true also of ortho-compounds.

Since that time, it has been experimentally demonstrated by various chemists that the radicles, Cl, Br, I, NO_2, SO_3H, can all be introduced in place of the hydrogen of the amino-group of anilines and of the imino-group of anilides, and that the compounds thus formed can be

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